
BARCELONA – How It Works: Internet Networking
Monday, October 22, 2018 – 15:15 to 16:45 CEST
ICANN63 | Barcelona, Spain

UNIDENTIFIED MALE: ICANN63, Barcelona, 22 October 2018, 15:15-16:45, How It Works, Internet Networking.

CATHY PETERSEN: Good afternoon, everyone. We will be starting our How It Works on Internet Networking shortly. We'll just give it a few more minutes. Thank you.

Good afternoon, again, everyone. Welcome to our How It Works on Internet Networking. Presenting is Alain Durand, our Principal Technologist from the Office of the Chief Technology Officer at ICANN. Go ahead.

ALAIN DURAND: Good afternoon. Thank you very much for coming to this session. I would like to make this interactive so I'm going to ask all of you who are in the back to move to the front table so at least we can all face-to-face and maybe you can play some games later on during the presentation. Thank you very much.

So as I said, I want this to be interactive, so please interrupt me, okay? Ask questions and if I don't know, then I will say, "I don't know." Okay, so let's go.

Note: The following is the output resulting from transcribing an audio file into a word/text document. Although the transcription is largely accurate, in some cases may be incomplete or inaccurate due to inaudible passages and grammatical corrections. It is posted as an aid to the original audio file, but should not be treated as an authoritative record.

So this tutorial is aimed at people who are not technologists, who work in the ICANN community and would like to have a refresher on what are the basic technologies that we are talking about here, like naming, addressing, routing. But this is introduction level, so we are not talking about very complex BGP AC or anything like that. Try to make it understandable to everybody.

So if you are an expert on TCP/IP, maybe not the best use of your time here. If you would like to know it a bit more because you have been wondering how this thing works, hopefully this will provide some answers. So, next.

First, I would cover some fundamental technology elements [inaudible] networking by numbers, like painting by numbers, try to make it easy. And when we will talk more about naming, addressing and routing and all of those things relate to each other.

So first, technology. Next slide, please. All right, so you probably have heard somehow, somewhere about the OSI model and the seven layers of the OSI model. Well, I am going to describe them more starting from zero to nine, so that's ten layers.

This is a conceptual model. This is not meant to be taken too seriously and when people are implementing things on the Internet, they certainly don't go through those layers, but help us to understand the concept. So, next.

The first thing is layer zero, is what is the physical thing that we are using? So when we are sending information, there are fundamentally

two different types of techniques. Either we send them over a cable or over the air. So cable, it could be copper and it's an electric signal or it could be fiber and it's a light signal. But fundamentally, that's the same thing. There's a piece of cable that has to be deployed, and typically, you will see that in cities. People are digging a trench and they are trying to get these huge cables to be underneath the pavement.

That will mean that in the city, you may need authorization to do that. You may have to go to City Hall to provide you an authorization to go and dig a trench. You may have to compete with other people who want to do exactly the same thing. You may re-use some of those conduits which have been put in place by other people if they give you the right to do that. Sometimes you have to buy it for 99 years or something like that.

That's a fairly expensive proposition. Usually, it's done when you have a high density of population like a big city and you can have high volume of data to move and you, more importantly, have a lot of customers that can use this.

I'm trying now to live in the mountain area. This is not a solution for me. It does not work because I would be the only person in 20 kilometers around that wants something like this and maybe even with ten of us or even 100 of us, that will still not be enough.

So the other type of connectivity is through wireless, so essentially an antenna or cell phone, something like this. It's great in open areas, typically in the rural area, because you can cover a lot of distance with

just one antenna. Sometimes you can cover ten kilometers or 20 kilometers if you have line of sight. If you don't have a mountain in the middle, if you don't have a massive forest and a lot of trees in the middle, that's great.

If you're in the city, it's kind of bad because you have a lot of people who want to connect to you and it's a lot of power signal and signal bounce from building to building, so you have a lot of interferences. Some are problematic.

But the other problem that we have in this is, see this antenna on the top of a historical building here? It's ugly and nobody wants to see that. You can get the pointer here. Yeah, that thing here.

Plus in some cities or some countries, you have also regulation about historical buildings. You cannot do what you want. This is not allowed in many places. So it's sometimes a trade-off. Do you want Internet or do you care about the building? The answer is different from place to place.

So in suburban area, this is actually something that you see a lot, not on the [inaudible] building, of course, but on the big tower, you will see those things. It's really nice to cover a lot of territory except in very affluent neighborhoods. I used to live in Washington D.C. in the U.S. and in one of the neighborhoods which was quite nice and the Internet from [inaudible] signal was really, really bad.

Why? Because the neighbors there didn't want to see any of those antennas in the neighborhood. They thought, again, it was ugly or

they had concerns about radio signals and their health or whatever it was.

But the point was people were noisy enough, powerful enough, to say no. So they made a different trade-off to say no to the Internet for wireless, we just want our nice neighborhood. That happens. But they're perfectly willing to pay a lot of money to get fiber, so that's how it works.

So you see where you have really two different ways to bring the Internet and they have different set of consequences. The type of data, type of bandwidth, you can get over the air or over fiber are completely different. Typically, with over the air, if you get one or two megabytes per second, it's kind of good. If you get three megabytes, you are very happy already, or I am, at least, very happy. That's what I have now in my house. If I can get 10, 20, 30, 50 [inaudible], that's wonderful. But you don't always get that.

Most of the time, the bandwidth is going to be shared with all the people who connect to the same antenna. So you may have a technology like 3G, 4G, now 5G that promise you can get up to gigabytes per second, but if you have 1,000 people sharing one gigabyte per second, that makes one megabyte per second, right? So you have to be a little bit careful about how you look at those numbers.

On the fiber here, a typical fiber today, you can get ten gigabytes per second no problem. Most networks are built like that. Or it can be a multiple of that. We are going to talk about this.

The fastest we can go today with equipment you can buy off the shelf is 100 gigabytes per second. You can go to 400 gigabytes per second. I have seen a presentation last week about that. It's still alpha hardware. It's not even beta. It will be ready as a product in a few years maybe or a few months. I'm not sure and this will be certainly [inaudible] expensive and when it will come.

What most people would like would not be 400 gigabytes, but it would be at least a terabyte per second. One hundred gigs, we started to play with it back in 2008. We're in 2018, ten years later, and we have not been able to go 10X and that's a problem because what we are seeing is that the consumption of data on the Internet is growing enormously but the technology to actually push it over a fiber has not grown at the same pace. Or more specifically, people are not willing to pay the price it will take to grow at the same pace. So there is a bit of a discrepancy here.

Anyway, let's moving on. So let's talk a little bit more about those fiber and let's say that I want to send data from, let's see here – let's pretend that this white cable is a fiber – all the way to the computers at [inaudible]. So fiber is light. We send light over fiber. We don't send electricity. The computer is electric. There is no light in the computer. It's just electric.

So how do you transform light to electricity or electricity to light? Well, electricity to light, you use a laser, the same thing as with laser pointer here. And if you send it to our fiber, the fiber is going to conduct the light all the way to the other side, not in a straight line but following

the fiber and on the other side, you have an electro cell that is going to receive the light and transform this into a zero or a one or electricity, zero volt or five volt.

If you want to go faster, all you need is electronics that goes faster at either sending the signal, sending the light, or stopping it. When the light is on, it's a one. When the light is off, it's a zero. So if you do that once per second, you have one beat per second. If you do that 1,000 times per second, you have one kilobyte per second. If you do that 1 million times per second, you have one megabyte per second. If you do that 1 billion times per second, you have one gigabyte per second. So you really need to go really, really fast if you want to go to the type of speed we were talking about earlier.

But now, okay, I want to send this information from there to there. I can send electricity which will be converted into light, converted back to electricity on the other side. It's point-to-point, from here to there.

Now let's say that you and I would like to use the same fiber. If we send light, when I send light, you send light, how do they know and [inaudible] decide whether it is me or you? So we are going to use a convention, colors. Dennis is your name, right? What is your favorite color?

[DENNIS]: Blue.

ALAIN DURAND: Blue. All right. Peter, what is your favorite color?

PETER BREDGAARD: Violet.

ALAIN DURAND: Violet. Okay, I will take red. So the three of us want to share the same fiber. You will send the light with a violet color. You will send it with a blue color and I will send it with a red color. On the other side, there will be a filter that will say, “Oh, if it is red that I’m receiving, I know it is from me. If it is violet, I know it is from Peter. If it is blue, it’s from Dennis.” That way, we can share the same fiber simply using different color wavelengths. And you can put quite a lot of them in the same fiber.

But this is only from here to the computer over there. As I said, it’s point to point. Now imagine that I want to send data from here to my office back in Washington D.C. So you say, “Okay, we are going to have this meeting in Barcelona and I am going to ask for a sheep to start going, crossing the ocean, and drawing a fiber all the way from Washington, from the Chesapeake Bay to the Atlantic Ocean to [Fujiwata] maybe and [inaudible] turn and see into a pot here. That would take forever and that would be very expensive. So nobody does this.

So if we want to send whatever fiber from here to Washington, we’re not going to have a single fiber. What we are going to do is to create what we call a fiber path. We know that we have one fiber from here to

maybe a central office in Barcelona. There might be another fiber from the central office all the way to Spain on the other side facing the Atlantic Ocean and another fiber from there across the Atlantic to maybe New York City and another fiber from New York City to Washington.

Each of those fibers may be used by different people, but we are going to connect them and create this path and we may start with you will be sending blue from here to the central office, but from the central office to somewhere else, maybe blue is already used by somebody so we will give you green instead, and we may change colors at each point. It's okay as long as the operator patching all those fibers together, making the table that says, "This color on this segment belongs to Dennis. This other color on this other segment belongs to me." And it's just about matching those point to point, so we can now create a communication from here all the way to, well, this side of Washington D.C. or maybe somewhere else. It may be that I have asked the operator for fiber from here to Washington. You may have asked the operator for a fiber from here to, where is your office?

UNIDENTIFIED MALE: Copenhagen.

ALAIN DURAND: Copenhagen, so maybe you will not have to go to New York. It will be better for you if you could go straight from maybe Barcelona to

Copenhagen. But we may share a bit between here and the central office.

The point I am making here is you never know who you are sharing the fiber with. It is not yours. And you may not even know where the fiber is going. Actually, how would you know if a fiber is going for New York or not? Any idea? Let's say that you talk to your service provider, say I want a fiber from here to Copenhagen and you say, "I want it direct," but they send it to New York. How would you know?

UNIDENTIFIED MALE: Answering time.

ALAIN DURAND: Yes, that's the answer. You send some light. From here to Copenhagen, if you go direct, maybe about 2,000 kilometers, 1,500, something like that. So the light goes 300,000 kilometers per second. If you go there and back, it's 3,000 kilometers so it should take one millisecond, essentially, more or less. Maybe more because of a couple of routers but we are talking about maybe a couple of milliseconds.

If you want to go to New York and back, you have to go 3,000 kilometers over the ocean, another 3,000 kilometers to go back plus a few more or less, so we are talking about ten times more. So instead of maybe taking five or ten milliseconds, it will take 100 milliseconds. So if you time with a clock, the packet you send them over there and back so you have the same reference in your clock. And if you see round trip of about ten milliseconds, maybe 20, it's direct. If you see a round trip

of 200 milliseconds, your service provider lied to you. That's how you detect those things.

So fiber path, we just talked about it. Now that we can connect things together, we are going to build networks. The beauty of networks is one simple sentence. My network, my rule. I want my network to be used by my users and apply the rules I want where. If that is you want your network, your rules. You get to isolate your network.

[Aaron], that's your name? You want your network. You can isolate your network. Your rules. Now something interesting happened. You have some users and they want to talk with people that are users of Dennis's network. How are we going to do that? Your network, your rule, his network, his rule. What we are going to connect those things together, so maybe the two of you have a network that has a point in common. You can find an exchange point somewhere in the city. So which country are you from?

UNIDENTIFIED FFEMALE: U.S.

ALAIN DURAND: Okay, so maybe his service provider lied to him and is sending his data to New York and you are based in New York, so maybe you can find a connection point in New York. And that works for a while until Dennis realizes that actually, his service provider lied to him and changed service providers so now I can go directly to Copenhagen and you are not in Copenhagen. Maybe I want a network that is in Copenhagen

that is also in New York, but I have no connection with any of you. Maybe you can make a contract with me. I will make a contract with you.

So when you want to send data to users that are Dennis's network, you send me the data, I send them to you, and vice versa. Really or not? Maybe not. You don't necessarily need to use me. Maybe you have another contract with Peter because it's cheaper for you than to have a contract with me. And Peter may have a contract with Joseph, and Joseph has a contract with [Aaron] and in that case, you go on the return for a different route. That's one thing that's important on the Internet. We always think that there is symmetry. If I can go from A to B, B will come back to me. That's not true. It all depends on the contracts that have been put in place.

So Internet is about creating networks of networks. It's all about how do we connect with networks that are fiercely independent, my network, my rule, and I want to make contract with whoever I want and nobody else, and how to make all these things work together.

So that's why the Internet is spelled with a capital I, not a lowercase i, because it's a network of networks. That's really what it is.

So in this community at ICANN, very often we hear people talking about IP and "I have IP this", and "I have IP that," and you are violating my IP". They mean intellectual property. What they really, really mean is intellectual property rights, IPR.

In technology, IP really stands for Internet Protocol, so there's a little bit of an overlap in terminology here. So in this room today, IP means Internet Protocol. That's the protocol we use to communicate from one network to the next.

So now we have a nice network. Everyone, users can send data from me to Dennis and you can respond by talking to [inaudible] users using this longer network, but still a network all the way back. Okay?

How do your users know that on the other side, they receive the communication? You send data. I can send. Let me send data with Cathy over here. And let's say I have a file, a big file. I'm going to cut it in chunks, ten chunks, and I am going to send them over the network. Cathy, this is my new file, ten chunks, chunk one, chunk two, chunk three, chunk four, chunk five, chunk six, chunk seven, chunk eight, chunk nine, chunk ten.

CATHY PETERSEN: Ack.

ALAIN DURAND: Oh, I just heard something, "Ack." She responded back to me saying that she has received it. Which part has she received? All ten, just the first part, part number five? I don't know.

So if you don't have really a more complex protocol that says, what has been received by the other side, it doesn't really work. So that's what this TCP protocol that you have heard about, I'm sure, is all

about. This is first making sure that we can talk to each other and then sending the traffic and making sure that all the data has arrived.

So first thing, we are going to talk together, establish a communication. We need to make sure a couple of things. First I want to talk to her and I want to know that she hears me because if she doesn't hear me, there's no point in me talking, right? Then she wants to know that she hears me. But she wants also to know that I know that she hears me because if she hears me but I don't know that she hears me, it's the same for me as if she does not hear me. I can just shout in the dark, makes no difference.

So this is a three-way thing. First I am going to send a small packet to simply say, "Hello."

CATHY PETERSEN:

Ack.

ALAIN DURAND:

When I hear the "ack", I know that she has received something from me. She has heard me and then she said, "Ack." I know but I can hear her. The one thing that is missing is she still doesn't know if I've received her "ack" or not so I have to respond. Ack. At that point, she will know. That's three packets, one, two, three. That's the only way to actually know that we can have a communication that's a reliable communication.

And now I am going to send my file, and I am going to cut it in chunks.
But I'm going to wait after each chunk. So chunk number one.

CATHY PETERSEN: Ack.

ALAIN DURAND: Chunk number two.

CATHY PETERSEN: Ack.

ALAIN DURAND: Chunk number three.

CATHY PETERSEN: Ack.

ALAIN DURAND: Chunk number four. Nothing. So she has heard the first three parts, not the fourth part. Something has happened. What could have happened? Any idea? Suggestions, comments?

UNIDENTIFIED MALE: Packet lost.

ALAIN DURAND: Packet lost, yes, but where?

UNIDENTIFIED MALE: In transit, maybe entered somewhere else?

UNIDENTIFIED FEMALE: I was going to say the same thing. Transit.

ALAIN DURAND: Yes. So something happened. The packet is lost and the actual answer is I don't know where it's lost. I have no clue. So it could be, for example, that we were using this fiber and the fiber was cut at that very moment. Before it was fine and after packet number three, fiber was cut. That's a possibility. Or it may be that I was using Dennis's network and something happened, fire, whatever, [water] crashed. Or we are using Peter's router and Peter's router got overloaded at that very moment. He had too many things coming in, not enough bandwidth coming out. Or it could be that we were using Joseph's wireless infrastructure somehow and it was wireless and there was a big storm, lightning strike the tower at that moment. The tower is okay, but for a few milliseconds, there is too much static electricity and nothing works. Or it could be that, what's your name?

[STEPHANE ROBINOT]: [Stephane].

ALAIN DURAND: [Stephane]. It could be that [Stephane] was on the other side of the wireless network but she's by the road and a big truck that was coming in at that very moment and she has bad reception in the network somewhere and the truck was just creating too much interference. It could be any of those reasons or all of them combined. The point is we don't know, but we know that the network somehow has had a problem. So what should I do? Well, I should simply start again. But I'm not going to start from the beginning. I know packet number one, two and three made it through it. Okay, I'm going to send packet number four.

CATHY PETERSEN: Ack.

ALAIN DURAND: This time it went through. But then I am going to scratch my head and say, "Really, what could have happened that went wrong?" Is it really possible that in the two microseconds between packet three and four, the fiber was cut? Nah, don't believe it. Is it possible that this truck was passing [inaudible] network? Nah, don't believe it. That the lightning struck the tower? Eh, maybe. Just one millisecond? Nah. Most probably, and some studies have demonstrated this, the problem was congestion somewhere. There was one router, in that case, in your network where too [inaudible] was coming in and not enough was coming out.

It means that too many people are using the network. If you all keep sending traffic at the same speed, we will have the same problem over and over again. So what needs to happen is everybody has to slow down. So in the TCP protocol, what we are going to say is, “If we lose packets, let’s interpret this as the network is congested and slow down.” So instead of saying, “Packet one, ack, packet two, ack, packet three, ack,” now I know I’m at four. I’m going to say, “Packet... four...”

CATHY PETERSEN: Ack.

ALAIN DURAND: Okay? I am going to slow down and everybody else is going to slow down at the same time, so now Peter’s network is relieved because everybody else is taking a deep breath. But now there might be enough bandwidth in Peter’s network and we can all accelerate, so we are going to go a little bit faster for packet five. It will be, “Packet.. five.”

CATHY PETERSEN: Ack.

ALAIN DURAND: Okay. I’ll go faster. Maybe I can try faster. Packet six.

CATHY PETERSEN: Ack.

ALAIN DURAND: Packet seven.

CATHY PETERSEN: Ack.

ALAIN DURAND: Packet eight.

CATHY PETERSEN: Oh no, that was really too fast. So now I need to back up again. If we do that properly, we can find the optimal speed at which we can send data if – that’s a big “if” in the Internet – if everybody does that, if everybody behaves, then the network would function at this optimal level.

Now do you believe that people will behave on the Internet? Let’s make a test. Do you believe people will behave?

UNIDENTIFIED FEMALE: No.

ALAIN DURAND: Do you believe?

UNIDENTIFIED MALE: No.

UNIDENTIFIED MALE: No.

UNIDENTIFIED MALE: No.

UNIDENTIFIED FEMALE: Definitely not.

UNIDENTIFIED FEMALE: No.

ALAIN DURAND: No. Cathy?

CATHY PETERSEN: No.

ALAIN DURAND: No. Do you believe people will behave on the Internet?

UNIDENTIFIED MALE: No.

UNIDENTIFIED MALE: No.

ALAIN DURAND: No, no. Do you believe people will behave?

UNIDENTIFIED MALE: No.

ALAIN DURAND: Do you believe?

UNIDENTIFIED FEMALE: It's been proven no.

ALAIN DURAND: Yes, she is right. It worked. But the most amazing thing on the Internet, back in the mid-1990s, people were saying, "It will never work. People will never do this." But that's for one case, or maybe a couple, but one of a very, very few cases where the good of a community was stronger than the good of individual people. And all the people who are actually writing applications, and I'm talking about brother vendors working at microseconds, all of them have relied on this type of mechanism or something similar because they understood that if they did not, then the truck would simply collapse. So it was a critical thing and they all believed that actually they had to do it and they did. Absolutely amazing is none of you, except you, believe they will do it but they did. Amazing collaboration effort.

So let's move on. Session is when you send a movie, you want to describe, for example, what is the type of end coding. Is it MPEG-4? Is it MPEG-2? Is it H.264, whatever it is? What is the length of the movie? So you want to describe all of that. So that on the other side, you know what to do with the packets.

Let's say that I send data that is a movie. We started talking about, but I don't tell you how many pictures per second, how many frames per second. Is it 24 frames per second or 25 frames per second? In Europe and in the U.S., it's different standard. If I don't tell you that, what are you going to do? You are going to make some assumptions because in your country, this is 24. Maybe if my country is 25, it is going to be weird. Right?

So this is really important to describe what you are going to send. If not, it's just garbage later and you simply consume a lot of bandwidth, expensive bandwidth for garbage data so not very useful. That's what the session [inaudible] is about. And how do you describe it for something? It's called a presentation layer where you use some text in that case here to describe what it is.

So in that case, what was sent was not a movie but was some kind of an application that has a menu and you can describe what are the different elements of a menu. This is one of the new technologies called JSON that all the new kids in town are using this to code their website.

A few years ago, the cool technology was called XML. Before that, the cool technology was called ASN.1. Every five or ten years, there is

something new and kids deploy this thing and they think that people before them knew nothing, which is partly true, but not entirely.

So it's not that one is perfect. It's just that we've learned after ten years that yeah, we could have done this a little bit differently. Let's try something else. That's just what it is.

So this allows to create meta-representations of the data. But none of this matters. Absolutely none of this matters. What matters is this. There's a kid on his bed browsing the web or playing with Whatsapp or whatever application it is. The rest is essentially pipes, plumbing. For the majority here, the population of this planet, it does not matter. What they want is to be able to use the iPad, computer, whatever it is, and watch whether it's a movie, chat with your friends, whatever they care about.

Those, kids like ten years old, those are our customers. If they want to do something and they can't do it and their friends can do it, they will not be happy. They will make their parents' life miserable and will force their parents to actually change service providers and make sure it works. That's the ten-year old economic of the Internet because since 1993 when NSF Net changed their Internet from a resource network to a commercial endeavor, what really matters is financial.

If you want to have those fibers going across the Atlantic Ocean, all those wonderful cell towers with 4Gs, 5Gs, somebody has to pay for it. Whoever is going to pay for it wants some return on his investment. Return on investment comes from the kids or actually, the kids'

parents. So if you want your network to be useful and make money, you need to make those guys happy. It's very simple.

Now there may be competing interest on how to do that. How do you resolve those problems? How does a community get together to decide how we are going to resolve problems? So there are different models. The model that we use at ICANN is essentially this one here where we put everybody in the same galaxy, that's the ICANN meeting, and [ever] we talked about those problems until we find a solution. That's a multi-stakeholder model. There are other models that exist, but in ICANN, that's what we are doing.

Political should not be constructed as something bad. It's simply the way people in a community make a decision. There can be good ways. There can be bad ways. The way we do it within ICANN is a multi-stakeholder process.

So now we have gone through zero to nine of the 7-Layer OSI Model. It's just extended a bit on this end. Now you have all BLM and [surf] technology to talk about what this is really about now, naming, addressing, and routing. So I'm going to make a quick pause here if you have any questions on this segment before I go to the next one.

UNIDENTIFIED MALE: [inaudible]

ALAIN DURAND:

Layer four. Very good question. I thought about TCP. UDP is simply I send data and I go away. It is like I'm home, I said to my wife, "Oh, I'm leaving." I close the door and I go away. Did she hear me? Maybe, maybe not. That's UDP. Is it useful? If you are in a hurry and you don't really care if she has heard you or not but you just want to have the back of your head clear, that's fine.

On the Internet, is it useful? Yes, actually, it is useful. This TCP thing, when the data has been lost, we try again. But sometimes the data is only good for maybe ten milliseconds, typically in a voice conversation. Let's say I start a voice conversation. I say, "Anne, I am going to talk to you. I am going to talk to you, you, you, talk to you, you, you, talk to," and I keep repeating "you, you, you" because the network thinks that there is packet loss and they send it again. That doesn't help you. You might as well have dead silence.

So all the voice communications across the Internet, they don't care if the data has arrived because the human ear is actually really, really good at reconstructing the message and it does a few things that, at last, it doesn't matter.

What matters more is that it arrives quickly and that it arrives in order because if I say, "How are you doing?" and you hear, "Doing are you how?" this is not going to help you. You better hear, "Are you doing?" if the "are" in the middle is lost, you can reconstruct the sentence. Your brain can do that.

So this notion that losing packets could be okay for some applications is actually quite important, [inaudible] being one of them or gaining would also be one of them. So that's why UDP is still being used.

UNIDENTIFIED MALE:

So they are in parallel? They run in parallel or are they replacement? So you do TCP and then in some cases, you use UDP?

ALAIN DURAND:

So an application is going to choose. If it's a voice application, it will choose to use UDP. If it's a data transfer application, it will choose to use TCP. That's how it's done. Another question?

Okay, so I talk about layer from zero to nine, but you should know that there are also layers in-between, layer 2.5 or 2.75 and things like MPLS for example. Or when we do encapsulation of IP within IP within ATM, we can do very complex things. So this is only a conceptual model to help us frame our mind on what this is about.

Okay, now we are talking about naming. This whole story started at the ICANN meeting in Buenos Aires a couple of years ago when I arrived there and I had a raging toothache, like really, really bad. And Cathy was there. She had arrived a few days before me and I knew that she had lived in Buenos Aires for a few years a while back.

So I went to see Cathy. Am I right if I remember that you were living in Buenos Aires there?

CATHY PETERSEN: Yes.

ALAIN DURAND: Oh, thank you. I really have this toothache. It's really bad. When you live there, I'm sure you must have known a dentist, right?

CATHY PETERSEN: Yes, I did.

ALAIN DURAND: Could you please give me the name of the dentist you were using back then?

CATHY PETERSEN: Sure. My dentist's name was Dr. Johnny Walker.

ALAIN DURAND: Dr. Walker, Johnny Walker. Maybe I can have some of his prescription and maybe that will help my toothache.

So now I am on a quest to find out more about Dr. Johnny Walker. What Cathy did was she gave me a name, right?

So what's a name? My favorite exercise is to go for a dictionary and look at things that I believe I know and try to find the exact definition. So a name is a word or a set of words by which a person, animal, place or thing is known, addressed or referred to.

So this is something that helps us to talk about something or to talk to something. Essentially, if I know your name, I know who you are. Dennis, I know your name. I know who you are. Okay? I can also talk to Peter about Dennis. You know your partner in crime in this networking, right? We can talk about him. Has he been doing good? Is his network reliable? We can talk about Dennis. There's two things. I can talk to you, to a name, or I can talk about a name.

But remember, if we forget all my ten OSI layer numbers, my TCP handshakes, that's okay. I want you to remember three things today. That's the first one. If I know your name, I know who you are. Yvonne, if I know your name...

YVONNE CAMPBELL: You know who I am.

ALAIN DURAND: Exactly. That's the number one thing. So this name, as I just said, is a handle. It's something that I can attach to a communication with somebody or to a communication with somebody else to refer a third party. That's what I said. We can talk to someone or about someone.

So in the example with Cathy, when I asked her, "What is your dentist's name?" we were talking about Dr. Johnny Walker. Now I want to talk to Dr. Johnny Walker because I want him to give me some of his medicine. I don't know if I want the red one or the black one or the blue one.

So names are funny. A little story, when I was in school in France, my first name is Alain, say “Alain” in French, and there were a bunch of kids my age that were the same name. In my particular classroom – I remember we were about 30-35 kids – there were six of us which name was Alain and we had a teacher that had this funny, funny thing. When she was not happy, she would say your name and say, “Go to the whiteboard,” or blackboard at the time. So she would say, “Alain, go to the blackboard,” and six of us were looking at each other and say, “Which one?” And then she would get really angry because nobody was going to the whiteboard, and she would say, “Alain, go to the blackboard,” and it was really getting a mess and then a lot of tension in the classroom, right? And teacher realized it was a problem and she would say which one of us had to go there.

So in the Internet, that’s the same thing. If you talk about the name of a computer and you don’t specify which one actually it is, if it is a local environment, that’s kind of fine. But if you are talking about the global Internet, it is not. So that’s why you need to specify fully sometimes, the name of a machine or a service.

But a name, that’s great. I know I need to go to Dr. Johnny walker but I have no clue where he is. So I need to go back to Cathy. Cathy, can you go back to your rolodex that you had when you were living in Buenos Aires and figure out where I can find Dr. Johnny Walker?

CATHY PETERSEN:

Happy to.

ALAIN DURAND: [inaudible]. That's the sound that a rolodex makes. Actually, now she is using a computer. That's much, much faster and less noisy. So where does he live?

CATHY PETERSEN: His address is 125 Root Canal Road, D.C.

ALAIN DURAND: We have to go to Root Canal Road. I know it's a long drive. It's a painful thing. But that's where I need to go. Now this is not just about the name. This is about where this person is. So what we have done here is transformed a name into an address. It's a process that's known as name resolution, so for those of you that were in here, we have a tutorial on DNS this morning or Saturday. We're talking about name resolution all the time. In this community, we talk about name resolution almost every single day. This is what this is. This is transforming a name like Dr. Johnny Walker into something like 125 Root Canal Road. That's really what this is about.

So this 125 Root Canal Road is an address. That's about where is the dentist. So again, looking at the dictionary. What's an address? Those are the particulars of a place where someone lives or an organization is situated. This is where you are. So Yvonne, let's remember. If I know your name...

YVONNE CAMPBELL: You know who I am.

ALAIN DURAND: Yes. Now let's cross the aisle. [Louis], if I know your address...

[LOUIS]: You know where I live.

ALAIN DURAND: Yes. Remember those old movies? "I know where you live." Remember those? That's exactly what this is. This is the second thing I want you to remember tonight. I know your name, I know who you are. I know your address, I know where you live.

So let's look at some examples of addresses. So I'm going to take the most famous house in Washington. That's where my office is. My office is not in the house there. It's next to it. The address is 1600 Pennsylvania Avenue NW, Washington D.C., some numbers, U.S.A. It's very famous. Everybody wants to go there. Every four years, there's a contest to decide who is going to live there. Probably the rent is free so people like to get there.

But if I look at the address, what we see if we start from the end is hierarchy. U.S.A. is the country. D.C. is the District of Columbia so it's like a state. It's not a state because when they created the capital city in America, they decided it would not be in any of the states, so they carved out some land and said it was not a state, it would be the District of Columbia. Washington is the name of a city. Northwest is

because the city cut into four quadrants. There's northwest, northeast, southwest, southeast. And then Pennsylvania Avenue, that's the name of a street. And 1600 is the number on that street. If I give you all of this in this structure, you know exactly where it is. You can put this address on a postcard. The postcard will arrive there. But it's a bit like UDP. You don't know if you will get an answer or not.

Not every single address is structured the same way. For example, for those of you who are familiar with the phone system in America, we have those numbers that are 1-800 and something else. Those are numbers that you can call. You don't pay. It's toll-free. Somebody else will pay for you. But you have no clue where the person is, maybe actually in India or somewhere else in the world.

You have a cell phone number. My cell phone number starts with 703, which is the area code associated with northern Virginia next to Washington but I'm here in Barcelona. So if you look at my phone number, you will think I'm an American living in America while actually, I am, this week, in Barcelona. So that gives you no information whatsoever about where I am.

Before the cell phone era, when you were receiving a call and you would see on the display, "This is coming from 703," you would say, "Oh, this is coming from northern Virginia. Do I know somebody in northern Virginia?" Maybe not, but going to pick up the phone.

IP addresses. If you look at an IP address, there's nothing in the structure of an IP address that will tell you geographically where it is,

absolutely nothing like an IPv4 address, like, I don't know, 129.30.12.6. It doesn't tell you where it is.

Now there are people who have created tables to map out both IP addresses to a particular location. This is called geolocation because there's nothing in the address itself but by looking at other database, figure out which service provider has been allocated that prefix or using techniques like how many milliseconds does it take to go there from different points. You can do triangulation and figure out more or less accurately where it is.

Some of those database are free and the quality of the data is so-so. If you want better quality, you need to use a more expensive geolocation database. But none of them are 100% reliable and that's because there's no structure in the IP address that maps geography because IP addresses to map routing decisions to a service provider that [inaudible], not to geography.

So if you remember the story at school, I have another story now for you. If you live in France, you know Paris, city of light, whatever it is. It's easy to know which city you're talking about if you say Paris. If we're in Barcelona and I talk about Paris, people will mostly think about Paris, the capital of France.

In the U.S., there are 29 cities called Paris in different states. So there was this joke I had with my son when he was coming to visit me in Washington. I told him, "Okay, let's go and have lunch in Paris." He said, "Well, we are not going to take the plane to go back to Paris." I said, "No, no, no. We will drive." He looked at me like, "Drive? From

Washington to Paris?” “Yes, no worries.” So we drove and we went in northern Virginia to a small city, like maybe 200 people, one restaurant. That was called Paris.

There’s another very famous Paris in the U.S. If you remember, there was a Wim Wenders movie called “Paris, Texas”. They are everywhere, 29 of them. So if you simply say in an address, “I want to go to Paris,” if you’re local, that may be enough. Everybody knows the small city of Paris in northern Virginia. But if it’s worldwide, you may have a problem, same as the names. So you need to specify completely the address.

So back to Washington, if I say, “I’m going to go to 1600 Pennsylvania Avenue,” everybody knows where you are going. Everybody’s a lawyer there. They know exactly where you’re going. But if you say, “I want to go to 2000 New York Avenue,” it could be New York Avenue Northwest or it could be New York Avenue Northeast, and they are, essentially, five kilometers apart. So you really need to specify which one.

So same as names. You can use an address to go somewhere or you can use an address to talk about it. For example, Dennis, this root Canal Road, do you know if it’s a good neighborhood, safe?

[DENNIS]:

No.

ALAIN DURAND: You don't know. You have never been there. But we can have a conversation about it even if you don't know anything about it.

Now I can go back to Cathy. Cathy, Root Canal Road, is it a safe neighborhood? Should I walk there? Should I take a cab?

CATHY PETERSEN: I don't know.

ALAIN DURAND: You don't know. Same thing. We have another conversation about something, but she knows about the place but she doesn't know the specific details to answer my question. We can still have a conversation.

Maybe I can ask around and I will eventually find somebody who knows about Root Canal Drive, hopefully. Anybody knows? Should I take a taxi or should I walk? Nobody? All right. I'll take a cab. It's easier.

Now, an address is still not enough to really communicate with somebody. Let's say that I want to send a postcard here to this little house painted in white in Washington D.C. and I put this complete address, 1600 Pennsylvania Avenue Northwest, Washington D.C., U.S.A. I put the full address. I'm not saying simply Paris, not 29 Paris, full address, and I put it in a middle box here. What's magic that will make it arrive on the other side? Because for me, it's just magic. I put it in the box and it shows up on the other side. Because there are also

small house elves that are going to take the letter or postcard and carry it. But how do they do that? They do that because the letter is going, or the postcard is going to be picked up by the local post office and they may have an agreement with the U.S. Post Office and will find a way. Or back to the point that we had before, if you have a Spanish Post Office, you may have an agreement with me, let's say, the UK Post Office, and I have an agreement with Dennis that is the American Post Office. So because of his three-way agreement, we can actually make sure that the postcard is delivered. And sometimes there are situations quite surprising where it still works.

Two years ago, I went to Hanoi in Vietnam and I visited the Hanoi Hilton, which was a place where they had the prisoners of war. As you know, John McCain was a prisoner of war. He was a senator in the U.S. who passed away recently. The most impressive things to me that was prisoners of war were receiving during the Vietnam War, packages from their family. How could this happen? Two countries at war and we can still receive packages from their family.

The reason was that Vietnam had a relationship with the USSR at the time and the USSR had a relationship with Sweden and the post office in the U.S. had a relationship with Sweden. So they were simply following that chain. So it's not because two parties are on [inaudible] that you cannot actually communicate.

For me, that was really mind-opening because this exactly the same thing that happened in the Internet. You may not, the two of you, agree on many things but if you find all the people that would be

intermediary in both directions, then you can still communicate. So maybe it was a lesson.

So now I know the name of the dentist. I know the address of a dentist. How do I go there? I said that I will take a cab to go there. Why? Because if I walk there, I have absolutely no idea where to go. I don't know if I'm the auto, if I need to turn left or turn right. I'm completely clueless. But the cab driver will know. Why? Because he knows the city. Or if he doesn't really know the city, he will have a map or GPS or whatever it is that will tell him where to go because there is some kind of an infrastructure that he relies on.

So what is a route? Again, opening the dictionary, this is a way to go from Point A to Point B. So the cab driver, we look in the GPS and find, "Oh yeah, this is the way. I have to take this avenue, this other avenue, this road, third exit on the roundabout, and then I will arrive at Root Canal Road." That's a route. So this is the third and last thing I want you to remember today. So Yvonne, what's the first thing I want you to remember?

YVONNE CAMPBELL:

That if you know my name, you know who I am.

ALAIN DURAND:

Yes, thank you. [Louis], what's the second thing I want you to remember?

[LOUIS]: If you know where I am, it's because you know where...

ALAIN DURAND: If I know your address...

[LOUIS]: Because you know where I live.

ALAIN DURAND: Yes. If I know your address, I know where you live. That's the second thing. Okay, now we are going to have a third thing. [inaudible], if I know a route for you...

UNIDENTIFIED FEMALE: You know where I go?

ALAIN DURAND: I know where to go to find you, how to get there. Those are the three things I want you to remember. The rest, eh. If you remember the jokes maybe.

So how do we build routes? Let's assume that there is no GPS whatsoever, okay? No map. How do I go from Point A to Point B without maps? Well, there used to be those things in cities, not so much anymore, at each intersection, there were signs. This way you can go, if you turn left, you will go to the zoo. If you turn right, you will

go to the parliament. If you go straight, you will go to whatever district. Street signs sending directions.

And I was watching this movie the other day and it was just before the war where people were changing road signs to confuse the enemy in case of an invasion. Because the maps were not reliable, people were relying on signs. So if the signs send the wrong information, you confuse everybody.

So road signs are really important. This is how you actually find your way through a city for a number of intersections, right? So those things have to be put in place before any kind of communication can happen. If road signs are not in place before I go try to find Dr. Johnny Walker on 125 Root Canal Drive, I will never, ever find it.

So we are going to put a sign in place. The way we are going to do this is to start from the destination back to the source. So we are going to start from 125 Root Canal Road and then we are going to find a way to propagate this information. So let's say for a second that you are 125 Canal Road and [Assalam] is your service provider. So you know how to go to 125 Canal Road. You have a commercial relationship. She is your customer.

Now you have friends. You're a service provider. You have friends. That's your business to make friends. So you are going to tell all your friends that you know how to go to 125 Root Canal Road. So who are your friends? Who is your friend? What's your name?

[DAVY]: [Davy].

ALAIN DURAND: Livy.

[DAVY]: Davy.

ALAIN DURAND: Davy, sorry. Davy, you are his friend. Listen to him. Please tell him.

[DAVY]: Do you know where 125 Root Canal Road is?

ALAIN DURAND: No, no. you are going to tell him, “I know how to go to 125.”

[DAVY]: I know how to go to Root Canal Road.

ALAIN DURAND: You trust him. He’s your friend. Okay?

UNIDENTIFIED MALE: Yeah.

ALAIN DURAND: What are you going to do next? You are going to tell your friends. He is your friend, [Louis] is your friend. Please tell him.

UNIDENTIFIED MALE: I don't speak very English.

ALAIN DURAND: You say, "I know how to go there."

UNIDENTIFIED MALE: I know how to go there.

ALAIN DURAND: Thank you. [Louis], you have friends, tons of friends. Tell all your friends in the world. Shout.

[LOUIS]: I know how to get there.

ALAIN DURAND: Okay, perfect. [Stephane], you happen to be one of [Louis]'s friends. You are going to tell me because I am your customer.

[STEPHANE]: I know how you can get there.

ALAIN DURAND:

Yes, that's exactly what it is. She knows. She doesn't know how to get there, but she knows somebody who does. Again, in old movies, as you may have understood, I like old movies – I know a guy who knows a guy. Remember that? I know a guy who knows a guy. That's exactly what it is. You know somebody who knows somebody who knew how to go to 125 Root Canal Road. That's how it is and if you remember back in the TCP discussion, I asked you, "Do you believe people are going to do the right thing?" None of you believed it except you and it worked.

This is the other case on the Internet where it works because everybody believes each other. You all have relationships with your peers and you essentially all believe your peers and you make sure that what is announced by your peers is somewhat consistent what they announced yesterday, so if there is a kind of a problem, you can figure it out. Or if there's a problem, you will figure out, "There was a problem, this was new and it was not supposed to be there," but essentially, this is how it works today, by trust, by cooperation.

The same thing as the post office example had before where you can go from Point A to Point B where Point A and B are [inaudible] but you can still communicate because of this cooperation here. On the Internet, it actually works. This is the second example of something completely incredible, but it actually does work.

So when the work routes are set up, well, if I want to send or I want to go to Root Canal Road, I go to my favorite service provider, [Stephane] who tells me where should I go now.

[STEPHANE]: I have to ask [inaudible].

ALAIN DURAND: So you send me to Louis. All right, Louis. I am there. I need to go to Root Canal Road. Who are you going to send me to?

[LOUIS]: David.

ALAIN DURAND: Davy, where am I going to? This guy, all right. I need to go to Root Canal Road.

UNIDENTIFIED MALE: This way.

ALAIN DURAND: Yeah, I have arrived. That's Dr. Johnny Walker. Can I have some of the blue stuff? My tooth is really bad.

CATHY PETERSEN: I'll send it back around.

ALAIN DURAND: Exactly. You are going to send it back around. So this is how this Internet works. It's very simple. Actually, it's a little bit more complex

than that, but I tried to make it easy today. This is an introduction level class, right?

But the concepts are fairly simple. Remember three things. The first thing is I know your name...

YVONNE CAMPBELL: You know who I am.

ALAIN DURAND: Second thing is I know your address...

UNIDENTIFIED MALE: You know where I live.

ALAIN DURAND: And the third thing, I have a route for you...

YVONNE CAMPBELL: You know where to go?

ALAIN DURAND: I know where to go. Those three things. A name is talking about something in the identity. An address is where it is. Today is there. Maybe tomorrow is another place. Maybe Dr. Johnny Walker doesn't live on Root Canal Road anymore. He lives on the bridge maybe.

The route is how to go there. Maybe last year, I had to go for a bunch of different small roads. Now there's a tunnel that goes underneath and I can take the tunnel. It's a new route. On the Internet, that's the same thing.

Okay, so that's it. If you have any questions, now is a good time. Going once... going twice... sold.

Do you have a question?

UNIDENTIFIED MALE: No. I was just wondering. Do you know if his address is correct? That he's not malicious?

ALAIN DURAND: That's a very good question. Do I know that 125 Root Canal Road is malicious or not? So there are a couple places or a couple ways it could be malicious. It could be, first off, when I went to see Cathy and I asked her to look up her Rolodex, that there was a piece of ink that had dropped on the Rolodex card and she misread it. It was not Root Canal Drive. It was actually Root Canal Road, so she gave me the wrong address because there is a problem, technical problem, in the database. Or it could be that she didn't like me much and she sent me to a bad dentist. It was a kind of payback for some jokes I made last time. It could be that too.

Or it could be that one of those guys somewhere decided to send me somewhere else because they are the business arrangement, not with

Dr. Johnny Walker, but with Dr. Jamieson and Dr. Jamieson is on an island and he has lower prices on his practice and instead of sending me to Johnny Walker, they send me to Jamieson. That is also possible.

There could be also, when I arrived there, how do I know I'm talking to Dr. Johnny Walker? I've never seen him. Maybe he's actually somebody else who has bought a practice or it could be one of his assistants. Or it could be somebody that had, essentially, attacked the practice for that particular day and impersonate the dentist and he is going to drill a hole in my tooth because I don't know. I didn't pay my bill lat time, whatever it is.

It bores on to the question of would you trust and how do you verify that trust? So at each of those different steps in the process, we can apply different measures. For example, when we go form the name, Dr. Johnny Walker, to the address, 125 Root Canal Road, we can make sure there is no typo on the Rolodex card. How? By taking a cryptographic of the signature of the Rolodex card and making sure when Cathy is reading it, that it is the right card for the senior [inaudible] matches.

So I need to know that this is called DNSSEC. So when I know what the address is correct, when I go through the chain over here, I can make sure that each of the route is configured properly and there's a technology for that called [inaudible] where you validate all the announcements from your peers you know we are talking to.

When I arrived to my final destination, I can have the certificate telling me I'm actually talking to the right site. But if either site has been

completely corrupted and hijacked, at that point, my daytime will also be at risk in the end.

So those are some techniques that can be applied to mitigate some of the risk that you were talking about. Does this answer your question?

UNIDENTIFIED MALE: Yeah, it does. Thank you.

ALAIN DURAND: One more question. [inaudible], do you have a question? So thank you all very much and I think we actually have a few minutes left, so is there an announcement, Cathy?

CATHY PETERSEN: I don't have an announcement. I just wanted to thank everyone for coming and just wanted to remind that we have another How It Works starting at 5:00 with the Root Server Operators and so you have a few minutes to go and stretch your legs. But the materials for Alain's presentation have already been uploaded to the public schedule and the recording and transcript will be posted to the public schedule as well within a week or so. Thank you again.

ALAIN DURAND: And thank you all for your participation in my little games.

[END OF TRANSCRIPTION]